B. High-Strength Steel Stamping Project

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Objectives

- Determine how to accurately predict and/or control the amount of springback and other deviations from the desired stamping geometry for parts made from high-strength steel (HSS) and advanced high-strength steel (AHSS) prior to the construction of the production tooling.
- Develop part design and manufacturing process guidelines that can be recommended to automotive design and manufacturing engineers for the purpose of reducing springback and other part distortions common to the manufacture of higher strength steel stampings.

Approach

- Improve HSS stamping springback predictability through more accurate applications of finite-element analysis (FEA). This will require that we achieve a better understanding of residual stresses resulting from each combination of AHSS material, part geometry and deformation process.
- Achieve HSS stamping springback control by developing knowledge of part design geometries that reduce flange springback and die processes that control springback. Several different types of dies have been constructed or are on loan to the Auto/Steel Partnership for the stamping process development.

Accomplishments

- Identified processes to control springback, sidewall curl, and panel twist.
- Modified our research tooling for stretch-forming processes of AHSS automotive body structural components to neutralize the residual stresses that cause springback and sidewall curl. Good results have been shown for HSLA 350 and DP 600. General Motors and DaimlerChrysler representatives state that this information is now being used in their AHSS manufacturing process planning.

- Designed and built a new multiprocess master die (Figure 1) that is capable of producing a variety of part shapes and processes by adding subdies for specific part shapes. The master die has a high-pressure hydraulic cushion that can be programmed for various process control features (Figure 2). Two new subdies have been designed and constructed to provide data on AHSS stamping characteristics. These data will be used to develop additional AHSS design and manufacturing guidelines.

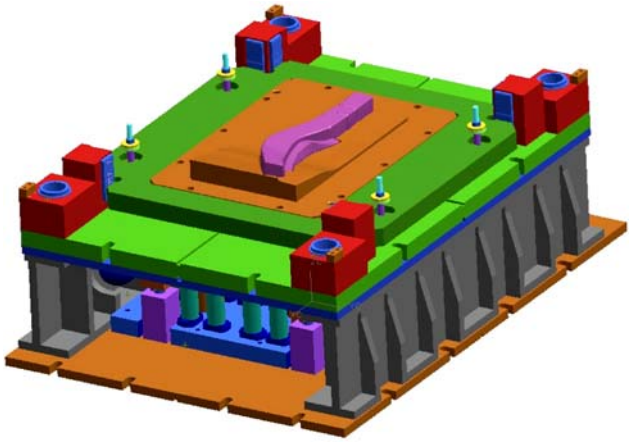

Figure 1. Multiprocess master die.

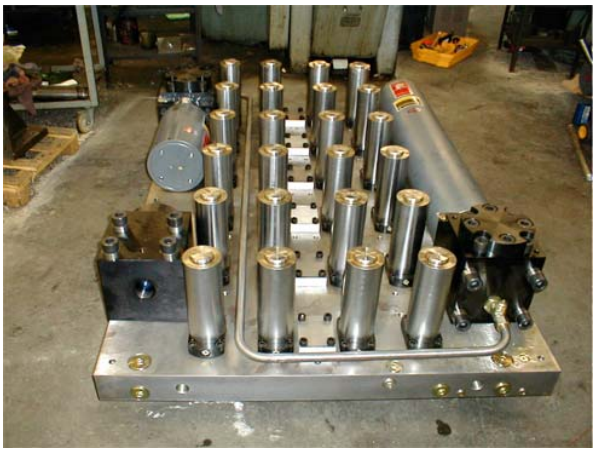

Figure 2. High-pressure hydraulic press cushion.

Future Direction

- Begin stamping experiments with our new multiprocess master die and programmable hydraulic cushion. This die is designed as a master die set and pressure system that will accept subdie inserts to produce a variety of AHSS structural parts and/or stamping processes.
- Focus on stamping AHSS thin gauge automotive structural members to replace the thicker gauge components in the body structure. Future possibilities for weight reduction also exist in the thinner gauge large panels, such as doors and fenders.

Introduction

Due to the mechanical properties of high-strength steels (HSSs), the springback after forming and the geometric dimensional control of the stamped parts has been a critical issue in stamping tool construction and in stamping production. Because the actual dimensions of HSS stampings off the tooling are unpredictable with current tools and

technology, the average die face remachining may be four to six times normal and result in 2 to 3 months of tryout time.

Computer simulation technology has been widely applied in the stamping industry and has been recognized as a common virtual stamping tool to identify formability issues and evaluate solutions before the actual stamping dies are made. Although computer simulation provides accurate prediction for splits and buckles, experience has shown that computer simulation data have not been reliable in predicting the amounts and modes of the springback, twist, or side-wall curl.

Springback and other distortions in HSS stampings may be controlled by innovative stamping processes that neutralize residual stresses resulting from the metal deformation. These processes will involve some type of stretch forming to give the stamping "shape set." The work of this project team is to determine the most effective means of researching and applying these "shape set" processes. Computer simulation is also being analyzed to improve the data input for accurate formability prediction.

In addition to the formability issues, there are other concerns regarding energy requirements and stamping press capabilities when forming higher strength sheet steels. Increased mechanical press flywheel energy and cushion pressures may be required to effectively work with AHSS. This project team will also focus its attention on manufacturing methods that minimize the energy requirements for working with the higher strength materials.

Deliverables

1. Improve the capability of computer simulation for predicting stamped part deviations, such as springback, from nominal.
2. Develop part design and manufacturing process guidelines to control or neutralize residual stresses that cause dimensional deviations in the stampings of AHSS.
3. Determine energy requirements and safe operating parameters to avoid damage to stamping presses when producing AHSS stampings.

Progress Toward Meeting Deliverables

1. All experimental stamped panels will be laser scanned for dimensional data. These data are then subject to data analysis, and the results for each series of experiments are provided in a written report to computer simulation programmers at the automotive companies. This information is then used to update their finite-element analysis (FEA) programs for AHSS.
2. Part design features and manufacturing processes that minimize dimensional variation are recorded and will be included in the revised High Strength Steel Stamping Design Manual. Part shapes that contribute to forming difficulties and dimensional variation will be identified for the product engineer's consideration.
3. Stamping presses used for these experiments are being instrumented to provide data on total tonnage requirements at impact and at bottom dead center. The impact loads are a major concern for press damage and flywheel energy dissipation. Press tonnage monitors will be used for recording the total tonnage requirements. Press signature analysis equipment will be used to monitor the impact loads.

Conclusions

The project team is currently proceeding with final tryout of the new stamping research dies and a high-pressure hydraulic cushion system. Installation and calibration of the press monitoring instrumentation is near completion, and the acquisition of sheet steels in the gauges and grades necessary to complete the design of experiments is under way. It is expected that collected data from these experiments will greatly enhance our knowledge for working with these materials and contribute to the increased application of lighter weight AHSS in future automotive products.